Seabed Dynamics in the Adriatic Sea and Western Gulf of Lions

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Award Number: N00014-04-1-0314
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LONG-TERM GOALS

The ultimate objective of this research program is to obtain a predictive understanding of the physical and biological processes responsible for the formation, alteration and preservation of sedimentary strata on continental margins. The general approach is to use focused field observations and measurements to develop and test hypotheses.

OBJECTIVES

During the past triennium this project has transitioned between analyses of data collected in the Adriatic Sea during FY01-03, conducting fieldwork in the Gulf of Lions (GOL) in FY05, and completing overall analyses from both locations in FY06. The Adriatic research has had two broad objectives. First, we are testing the idea that river-ocean coherence has a first-order impact on the initial distribution and character of strata in the coastal ocean. In particular, we hypothesize that moderate sized rivers (e.g., Po, ~10^5 km^2), in which discharge peaks are decoupled from oceanic conditions, produce thick beds that have large horizontal continuity and significant vertical (i.e., temporal) variation in physical properties. In contrast, small rivers (e.g., Apennine rivers, Eel, ~10^4 km^2) produce thin beds, which due to subsequent bioturbation have low horizontal continuity and little vertical variability. Second, we are exploring the idea that large-scale spatial variability in sediment erodibility may control accumulation rate patterns that have been observed in the western Adriatic (Po River to Gargano peninsula).

Our objectives in the Gulf of Lions are to extend, through collaborations with Patricia Wiberg, Tim Milligan and Paul Hill, our high-resolution porosity measurements within the context of the erodibility of fine-grained sediment. In this case we are focusing on whether there are cross-shelf gradients of erodibility in the western GOL, and what controls such gradients. In addition, we conducted a test deployment of a new bottom-boundary layer tripod that collects high frequency data on sediment porosity, thereby providing important information on small-scale temporal and spatial change in sub-seabed properties.

APPROACH

Our approach in the Adriatic and Gulf of Lions research has been twofold. First, we have used a variety of corers (box, kasten & hydraulically-dampened) to collect seabed samples in a wide range of sediment types (mud to sand) over varying depths (cm to m's) within the seabed. In shipboard and

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2006**	2. REPORT TYPE	3. DATES COVERED **00-00-2006 to 00-00-2006**
4. TITLE AND SUBTITLE **Seabed Dynamics in the Adriatic Sea and Western Gulf of Lions**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon State University,College of Oceanic & Atmospheric Sciences,Corvallis,OR,97331**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

land-based laboratories, we then use a variety of techniques to collect high-resolution porosity, roughness, textural and biogeochemical (e.g., exocellular polymeric substances, chlorophyll a) data for the erodibility studies, as well as digital x-radiographs and radionuclide profiles for the flood deposit studies. Second, through DURIP funding we have constructed an autonomous resistivity profiler (ARP). ARP is an extension of an earlier microresitivity profiler that can move in three dimensions and has data/power endurance of several months. Together with a stereocamera, bottom altimeter, and Sontek Hydra system (pressure, currents, temperature, salinity and turbidity), the ARP tripod was deployed at a 28-m site off the Tet River in the western GOL during late winter-early spring 2005. Besides the PI, personnel supported on this project included Andrew Stevens who completed his MS at OSU in 11/04, and then carried out diverse data analysis on a part time basis (0.2 FTE) until 1/06 when he took a job with the Coastal Marine Geology branch of the USGS.

WORK COMPLETED

During FY06, the PI has been actively involved in data analyses on three fronts. First, the current meter and resistivity profiler data from the ARP tripod have been calibrated and compared to other data sources obtained by French colleagues at CEFREM to check for internal consistency. Subsequently, these data have been shared with other project participants (e.g., Patricia Wiberg and Andrea Ogston) working on sediment transport patterns in the GOL. Interesting, but unexpected, patterns in seabed temperature prompted limited laboratory experiments that have ruled out artifacts from probe self-heating.

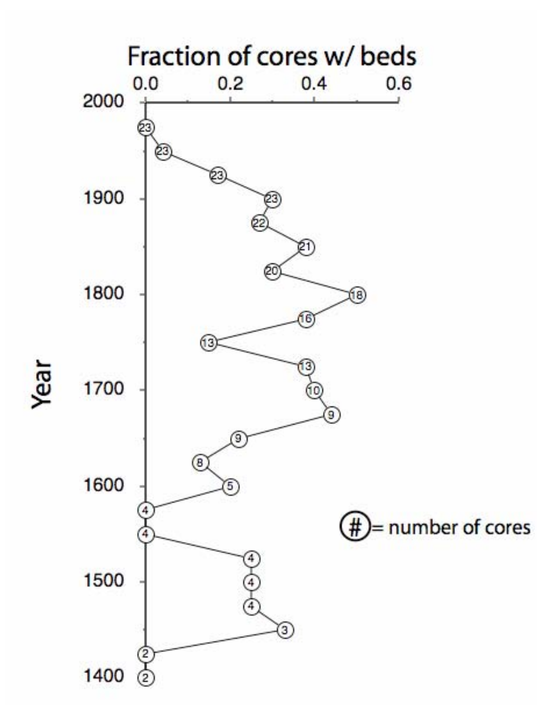

Figure 1. Graph showing the down-core fraction of cores with layers preserved over the past 600 years on the Apennine margin (western Adriatic Sea). There is a broad period of frequent (20-50%) bedding that corresponds to the Little Ice Age (1600-1850), but virtually no beds have been preserved during the past 50 y. Sediment depth was mapped to age by using sediment accumulation rates determined via Pb-210 geochronology (Palinkas & Nittrouer, 2007).

A publication describing the results of this field deployment is in the final stages of preparation. Second, we have fully processed the resistivity data from the Gulf of Lions and shared that with researchers at UVa and Dalhousie working on sediment erodibilitty. Third, we have used an objective edge-detection algorithm, first developed for analyses of the Po flood deposit (Wheatcroft et al., 2006), to quantify bedding frequency in kasten cores along the Apennine margin. Several manuscripts from this and earlier efforts are under preparation and revision (see list below).

RESULTS

Results of the Apennine kasten core analyses further underscores the key role of river-ocean coherence in determining margin sediment transport and the development of shallow stratigraphy. Briefly, the Apennine rivers are small, high-sediment-yield systems that are dominated by short-lived (1-2 d) precipitation events. Modeling indicates that under natural conditions Apennine rivers should produce frequent flood deposits in the coastal ocean, and in some instances should form hyperpycnal flows (Syvitski & Kettner, 2007). However, the objective analysis of >25 kasten cores collected along the Apennine margin indicates that strata are preserved in the subsurface (corresponding to 1600-1900 AD), but not in the upper 60 cm of the sediment column (Figure 1). The likely reason for this pattern is that the extensive flood control dams that were constructed following World War II has dampened the flood waves. Thus, sediment is introduced into the coastal ocean over periods of a few weeks to months, river-ocean coherence has been disrupted, and event beds are no longer formed.

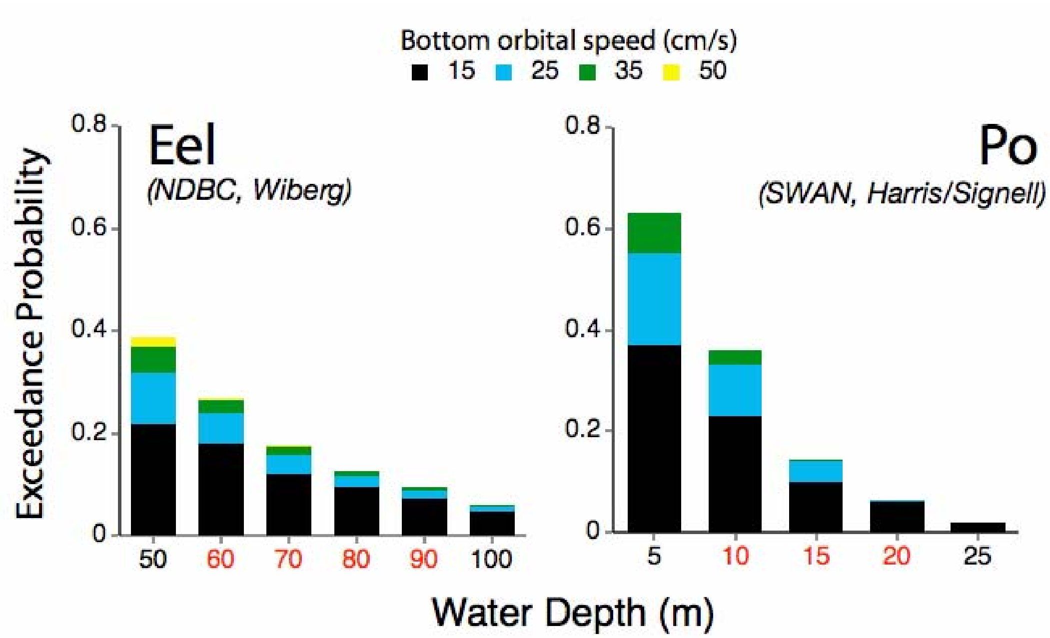

Figure 2. The exceedance probability of bottom orbital speeds (15, 25, 35 & 50 cm/s) as a function of depth for the Eel and Po river margins. The Eel estimates were made by Patricia Wiberg (UVa) using NOAA-NDBC data, whereas the Po estimates were made by Courtney Harris (VIMS) and Rich Signell (USGS) using modeled wind. In both panels, the depth of the flood deposits is depicted in red.

A second intriguing result that arises from our river-ocean research involves the question of energy level or coherence. The exceedance probabilities of wave orbital speeds on the Eel and Po river margins indicate that the wave climate at the depth of emplacement of the Eel and Po river flood deposits is approximately equal (Figure 2). That is, flood sediment accumulates on both margins within a similar bottom stress climate. These stress climates differ tremendously in overall depth (10-20 m on the Po, 60-90 m on the Eel), but their similarity does not imply that emplacement occurred under similar energy regimes. In fact, we know that the energy levels were significantly greater during emplacement of the Eel flood deposits, but that is because the Eel is coherent with ocean storms, whereas the Po is not. Thus, energy level is important in determining the depth of emplacement, but coherence controls the character (thickness, internal complexity) of the deposit.

IMPACT/APPLICATIONS

The concept of river-ocean coherence has potentially widespread predictive capacity. The timescale of river response is a strong function of river basin size, as long as river impoundments are taken into account. The timescale of ocean response is less variable (order days), and the frequency of ocean storms likely varies latitudinally. Both of these timescales may be determined globally using remote sensed data, thereby permitting testable predictions to be made regarding presence/absence and complexity of coastal strata and its associated acoustical impact.

RELATED PROJECTS

Our research is closely related to that of three other groups. First, we continue collaborations with Chuck Nittrouer and Andrea Ogston (University of Washington) documenting strata emplacement and post-depositional alteration in the Adriatic Sea (Po River & Apennine margin). Second, we are working with Paul Hill (Dalhousie University) and Tim Milligan (Bedford Institute of Oceanography) in determining the bed-scale property variations, especially grain size, of the Po flood deposit as imaged using the digital x-radiography system. Third, we are working with Patricia Wiberg (University of Virginia) on studies of spatial variability in sediment erodibility in the western Adriatic and Gulf of Lions.

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